US009259980B2

(12) **United States Patent**
Deniau et al.

(10) **Patent No.: US 9,259,980 B2**
(45) **Date of Patent: Feb. 16, 2016**

(54) **APPARATUS AND METHOD FOR DATA TRANSMISSIONS IN A TIRE PRESSURE MONITOR**

(71) Applicant: **Continental Automotive Systems, Inc.**, Auburn Hills, MI (US)

(72) Inventors: **Jean-Christophe Deniau**, Fenton, MI (US); **Brian J Farrell**, Troy, MI (US)

(73) Assignee: **Continental Automotive Systems, Inc.**, Auburn Hills, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/524,836**

(22) Filed: **Oct. 27, 2014**

(65) **Prior Publication Data**

US 2015/0042465 A1 Feb. 12, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/206,336, filed on Aug. 9, 2011.

(51) **Int. Cl.**
B60C 23/00 (2006.01)
B60C 23/04 (2006.01)

(52) **U.S. Cl.**
CPC ***B60C 23/0455*** (2013.01); ***B60C 23/044*** (2013.01); ***B60C 23/0442*** (2013.01); ***B60C 23/0461*** (2013.01); ***B60C 23/0462*** (2013.01); ***B60C 23/0472*** (2013.01); ***B60C 23/0479*** (2013.01)

(58) **Field of Classification Search**
USPC 340/444, 445, 447, 448; 714/776; 73/146, 146.2, 146.5; 370/508, 394, 370/347, 230
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,428,089 A * 9/1947 Mumma .... H04B 14/02 178/17 R
2,451,859 A * 10/1948 Mumma H04L 19/00 340/12.15
3,777,062 A * 12/1973 Ogawa H04B 7/2125 370/215

(Continued)

FOREIGN PATENT DOCUMENTS

DE 4492128 6/1996
DE 19503756 8/1996

(Continued)

OTHER PUBLICATIONS

"Sony Remote Commander Operating Instructions RM-V701/V801", 1998, Sony Corporation.

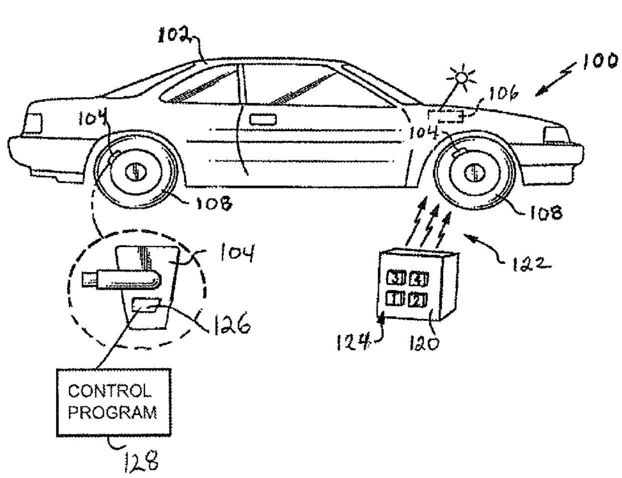
(Continued)

Primary Examiner — Paul Obiniyi

(57) **ABSTRACT**

A number of frames in a burst is adjusted such that a first optimal number of first frames from a first manufacturer are included in the burst, the first optimal number of frames chosen to enable the detection of the burst by first receivers that are tuned to receive the first frames from the first manufacturer. The number of frames in the burst is adjusted such that a second optimal number of second frames from a second manufacturer are included in the burst, the second optimal number of frames chosen to enable detection of the burst by second receivers that are tuned to receive the second frames from the second manufacturer. The number of frames in the burst maintains a configuration compliant with government regulations regarding one or more of a burst length and a power emission.

14 Claims, 11 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

3,814,839 A * 6/1974 Lubarsky, Jr. .... H04B 17/406 178/2 C
3,814,840 A * 6/1974 Lubarsky, Jr. .... H04M 3/28 178/2 C
4,589,063 A 5/1986 Shah et al.
4,703,359 A 10/1987 Rumbolt
4,734,674 A 3/1988 Thomas et al.
4,737,761 A * 4/1988 Dosjoub B60C 23/041 340/448
4,742,857 A 5/1988 Gandhi
4,774,511 A 9/1988 Rumbolt et al.
4,924,210 A 5/1990 Matsui et al.
4,959,810 A 9/1990 Darbee
4,999,622 A 3/1991 Amano et al.
5,061,917 A 10/1991 Higgs et al.
5,196,682 A 3/1993 Englehardt
5,201,067 A 4/1993 Grube
5,223,844 A 6/1993 Mansel
5,228,077 A 7/1993 Darbee
5,231,872 A 8/1993 Bowler et al.
5,243,430 A 9/1993 Emmons
5,255,313 A 10/1993 Darbee
5,303,259 A 4/1994 Loveall
5,335,540 A 8/1994 Bowler et al.
5,365,225 A * 11/1994 Bachhuber G07C 9/00015 340/5.26
5,414,761 A 5/1995 Darbee
5,434,572 A 7/1995 Smith
5,455,570 A 10/1995 Cook
5,515,052 A 5/1996 Darbee
5,537,463 A 7/1996 Escobosa
5,540,092 A 7/1996 Handfield et al.
5,552,917 A 9/1996 Darbee
5,562,787 A 10/1996 Koch et al.
5,564,101 A 10/1996 Eisfeld et al.
5,581,023 A 12/1996 Handfield et al.
5,585,554 A 12/1996 Handfield et al.
5,600,301 A 2/1997 Robinson, III
5,602,524 A 2/1997 Mock et al.
5,614,906 A 3/1997 Hayes
5,624,265 A 4/1997 Redford
5,661,651 A 8/1997 Geschke et al.
5,663,496 A 9/1997 Handfield et al.
5,698,353 A 12/1997 Jeong
5,706,247 A * 1/1998 Merritt G06F 12/0638 365/193
5,731,516 A 3/1998 Handfield et al.
5,731,763 A 3/1998 Herweck
5,732,283 A 3/1998 Rose et al.
5,741,966 A 4/1998 Handfield et al.
5,768,499 A 6/1998 Treadway et al.
5,808,558 A 9/1998 Meek et al.
5,838,229 A 11/1998 Robinson, III
5,841,390 A 11/1998 Tsui
5,844,131 A 12/1998 Gabelmann et al.
5,880,363 A 3/1999 Meyer et al.
5,883,305 A 3/1999 Jo et al.
5,900,808 A 5/1999 Lebo
5,926,087 A 7/1999 Busch et al.
5,959,751 A 9/1999 Darbee
5,963,128 A 10/1999 McClelland
5,965,808 A 10/1999 Normann et al.
6,002,450 A 12/1999 Darbee
6,005,486 A 12/1999 Fridley
6,011,463 A 1/2000 Cormier, Sr.
6,014,092 A 1/2000 Darbee
6,018,993 A 2/2000 Normann et al.
6,021,319 A 2/2000 Tigwell
6,034,597 A 3/2000 Normann et al.
6,078,270 A 6/2000 Shim
6,087,930 A 7/2000 Kulka et al.
6,112,165 A 8/2000 Uhl et al.
6,124,786 A 9/2000 Normann et al.
6,141,792 A 10/2000 Acker et al.
6,154,658 A 11/2000 Casi
6,155,119 A 12/2000 Normann et al.
6,169,480 B1 1/2001 Uhl et al.
6,169,907 B1 1/2001 Chang et al.
6,181,241 B1 1/2001 Normann et al.
6,192,747 B1 2/2001 Fennel
6,194,999 B1 2/2001 Uhl et al.
6,201,819 B1 * 3/2001 Luders H04B 7/2681 342/88
6,204,758 B1 3/2001 Wacker et al.
6,208,341 B1 3/2001 van Ee et al.
6,218,936 B1 4/2001 Imao
6,259,361 B1 7/2001 Robillard et al.
6,271,748 B1 8/2001 Derbyshire et al.
6,275,148 B1 8/2001 Takamura et al.
6,297,731 B1 10/2001 Flick
6,298,095 B1 * 10/2001 Kronestedt H04B 7/2643 370/318
6,333,698 B1 12/2001 Roddy
6,362,731 B1 3/2002 Lill
6,369,703 B1 4/2002 Lill
6,396,408 B2 5/2002 Drummond et al.
6,400,263 B1 6/2002 Kokubo
6,408,232 B1 6/2002 Cannon et al.
6,438,467 B1 8/2002 Pascai
6,441,728 B1 8/2002 Dixit et al.
6,445,286 B1 9/2002 Kessler et al.
6,446,502 B1 9/2002 Normann et al.
6,453,737 B2 9/2002 Young et al.
6,463,798 B2 10/2002 Niekirk et al.
6,469,621 B1 10/2002 Vredevogd et al.
6,477,165 B1 11/2002 Kosco
6,486,773 B1 11/2002 Bailie et al.
6,489,888 B1 12/2002 Honeck et al.
6,490,452 B1 12/2002 Boscovic et al.
6,507,306 B1 1/2003 Griesau
6,518,891 B2 * 2/2003 Tsutsui G10L 19/167 341/50
6,567,032 B1 5/2003 Mullaly
6,571,617 B2 6/2003 Van Niekerk et al.
6,612,165 B2 9/2003 Juzswik et al.
6,622,552 B1 9/2003 Delaporte
6,630,885 B2 10/2003 Hardman et al.
6,633,229 B1 10/2003 Normann et al.
6,662,642 B2 12/2003 Breed et al.
6,667,687 B1 12/2003 DeZori
6,681,164 B2 1/2004 Berghoff et al.
6,693,522 B2 2/2004 Tang et al.
6,704,364 B1 3/2004 Lim et al.
6,705,155 B2 3/2004 Katou
6,710,708 B2 3/2004 McClelland et al.
6,731,205 B2 5/2004 Schofield et al.
6,737,965 B2 5/2004 Okubo
6,738,697 B2 5/2004 Breed
6,747,590 B1 6/2004 Weber
6,750,761 B1 6/2004 Newman
6,774,778 B2 8/2004 Lin
6,778,380 B2 8/2004 Murray
6,788,193 B2 9/2004 King et al.
6,794,993 B1 9/2004 Kessler et al.
6,801,872 B2 10/2004 Normann et al.
6,802,213 B1 10/2004 Agrotis
6,804,999 B2 * 10/2004 Okubo B60C 23/0416 73/146
6,822,603 B1 11/2004 Crimmins et al.
6,828,905 B2 12/2004 Normann et al.
6,832,573 B2 12/2004 Evans et al.
6,871,157 B2 3/2005 Lefaure
6,879,252 B2 4/2005 DeZorzi et al.
6,885,282 B2 4/2005 Desai
6,885,292 B2 4/2005 Katou
6,885,293 B2 4/2005 Okumura
6,885,296 B2 4/2005 Hardman et al.
6,888,471 B2 5/2005 Elsner et al.
6,897,770 B2 5/2005 Lill
6,904,796 B2 6/2005 Pacsai et al.
6,906,624 B2 6/2005 McClelland et al.
6,910,627 B1 6/2005 Simpson-Young et al.
6,914,523 B2 7/2005 Munch et al.
6,915,146 B1 7/2005 Nguyen et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,915,229 B2 7/2005 Taguchi et al.
6,919,798 B2 7/2005 Ide
6,920,785 B2 7/2005 Toyofuku
6,922,140 B2 7/2005 Hernando et al.
6,927,679 B2 8/2005 Taguchi et al.
6,941,803 B2 * 9/2005 Hirohama B60C 23/0416 73/146.5
6,972,671 B2 12/2005 Normann et al.
6,983,649 B2 1/2006 Katou
6,996,418 B2 2/2006 Teo et al.
7,002,455 B2 2/2006 Buck et al.
7,010,968 B2 3/2006 Stewart et al.
7,015,801 B1 3/2006 Juzswik
7,017,403 B2 3/2006 Normann et al.
7,034,661 B2 4/2006 Lonsdale et al.
7,039,397 B2 5/2006 Chuey
7,042,348 B2 5/2006 Schulze et al.
7,050,794 B2 5/2006 Chuey et al.
7,084,749 B1 8/2006 Honeck et al.
7,084,751 B2 8/2006 Klamer
7,088,226 B2 8/2006 McClelland et al.
7,095,316 B2 8/2006 Kachouh et al.
7,096,003 B2 8/2006 Joao et al.
7,103,460 B1 9/2006 Breed
7,104,438 B2 9/2006 Benedict
7,113,083 B2 9/2006 Suitsu
7,116,213 B2 10/2006 Thiesen et al.
7,116,218 B2 10/2006 Ogawa et al.
7,120,430 B2 10/2006 Christenson et al.
7,137,296 B2 11/2006 Shida et al.
7,148,793 B2 12/2006 Lin
7,161,466 B2 1/2007 Chuey
7,161,476 B2 1/2007 Hardman et al.
7,164,117 B2 1/2007 Breed et al.
7,173,520 B2 2/2007 Desai et al.
7,224,269 B2 5/2007 Miller et al.
7,243,535 B2 7/2007 Shimura
7,254,994 B2 8/2007 Schulze et al.
7,307,480 B2 12/2007 Shiu et al.
7,315,240 B2 1/2008 Watabe
7,318,162 B2 1/2008 Rineer et al.
7,369,491 B1 * 5/2008 Beshai H04Q 11/0066 370/230
7,380,450 B2 6/2008 Durif
7,414,523 B2 8/2008 Li et al.
7,453,350 B2 11/2008 Kachouh et al.
7,478,554 B2 1/2009 Roth et al.
7,508,762 B2 * 3/2009 Ohtani H04L 12/403 370/235
7,512,109 B2 * 3/2009 Trott H04B 7/0851 370/347
7,518,495 B2 4/2009 Tang et al.
7,519,011 B2 * 4/2009 Petrus H04B 7/2656 370/280
7,535,841 B1 * 5/2009 Beshai H04L 12/5695 370/230.1
7,642,904 B2 1/2010 Crano
7,663,502 B2 2/2010 Breed
7,688,192 B2 3/2010 Kenny et al.
7,697,497 B2 4/2010 Grube et al.
7,817,543 B2 10/2010 Beshai et al.
7,884,707 B2 2/2011 Wittliff et al.
7,885,603 B2 2/2011 Santavicca
7,895,886 B2 * 3/2011 Tozawa B60C 23/0408 702/99
7,900,198 B2 3/2011 Kasman
7,948,364 B2 5/2011 Lin et al.
8,013,725 B2 9/2011 Murata et al.
8,019,323 B2 9/2011 Jheng et al.
8,027,359 B2 9/2011 Iwamura
8,031,598 B2 10/2011 Beshai et al.
8,035,257 B2 * 10/2011 Fornage G05F 1/67 307/140
8,049,533 B1 11/2011 Lin
8,082,579 B2 12/2011 Shimizu et al.
8,155,617 B2 4/2012 Magnusson et al.
8,185,093 B2 5/2012 Jheng et al.
8,319,378 B2 11/2012 Fornage
8,330,594 B2 12/2012 Suzuki et al.
8,332,104 B2 12/2012 Greer et al.
2001/0050611 A1 12/2001 Achterholt
2002/0030592 A1 3/2002 Laitsaari et al.
2002/0059825 A1 5/2002 Lundqvist
2002/0067285 A1 * 6/2002 Lill B60C 23/0416 340/870.11
2002/0075145 A1 6/2002 Hardman et al.
2002/0084895 A1 7/2002 Dixit et al.
2002/0086708 A1 7/2002 Teo et al.
2002/0121132 A1 9/2002 Breed et al.
2002/0126005 A1 9/2002 Hardman et al.
2002/0130803 A1 9/2002 Conway et al.
2002/0144134 A1 10/2002 Watanabe et al.
2002/0168795 A1 11/2002 Schuumans
2002/0186320 A1 12/2002 Carlsgaard
2002/0190852 A1 12/2002 Lin
2003/0005759 A1 1/2003 Breed et al.
2003/0009270 A1 1/2003 Breed
2003/0030553 A1 2/2003 Schofield et al.
2003/0050070 A1 3/2003 Mashinsky et al.
2003/0071723 A1 4/2003 Tang et al.
2003/0079537 A1 5/2003 Luce
2003/0080860 A1 * 5/2003 Stewart B60C 23/0416 340/442
2003/0080861 A1 5/2003 Okubo
2003/0095553 A1 * 5/2003 Shiomoto H04L 45/12 370/395.52
2003/0110851 A1 6/2003 Tsujita
2003/0112138 A1 * 6/2003 Marguet B60C 23/0433 340/447
2003/0117276 A1 6/2003 Marguet et al.
2003/0117277 A1 6/2003 Marguet et al.
2003/0122660 A1 7/2003 Kachouh et al.
2003/0131297 A1 * 7/2003 Fischel H04B 17/309 714/728
2003/0179082 A1 * 9/2003 Ide B60C 23/0408 340/425.5
2003/0197594 A1 10/2003 Olson et al.
2003/0197595 A1 10/2003 Olson et al.
2003/0197603 A1 * 10/2003 Stewart B60C 23/0444 340/442
2003/0197604 A1 10/2003 Ogawa et al.
2003/0228879 A1 12/2003 Witkowski
2004/0027241 A1 2/2004 Forster
2004/0039509 A1 2/2004 Breed
2004/0041698 A1 3/2004 Lin
2004/0061601 A1 4/2004 Freakes
2004/0113765 A1 * 6/2004 Suitsu B60C 23/0408 340/445
2004/0130442 A1 7/2004 Breed et al.
2004/0149025 A1 8/2004 Toyofuku
2004/0172179 A1 9/2004 Miwa
2004/0174246 A1 9/2004 Mitchell
2004/0203370 A1 10/2004 Luo et al.
2004/0215382 A1 10/2004 Breed et al.
2005/0039103 A1 * 2/2005 Azenko H03M 13/1515 714/776
2005/0046584 A1 3/2005 Breed
2005/0075145 A1 4/2005 Dvorak et al.
2005/0104722 A1 5/2005 Tang et al.
2005/0134446 A1 6/2005 Stewart et al.
2005/0156722 A1 * 7/2005 McCall B60C 23/0408 340/447
2005/0179530 A1 * 8/2005 Stewart B60C 23/0416 340/447
2005/0192727 A1 9/2005 Shostak et al.
2005/0264405 A1 * 12/2005 Ueda B60C 23/0408 340/442
2006/0001535 A1 1/2006 Hafele et al.
2006/0006992 A1 1/2006 Daiss et al.
2006/0012475 A1 1/2006 Froitzheim et al.
2006/0017554 A1 * 1/2006 Stewart B60C 23/0444 340/447
2006/0022813 A1 2/2006 Schulze et al.
2006/0025897 A1 2/2006 Shostak et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0044125 A1 3/2006 Pierbon
2006/0114107 A1* 6/2006 Kim B60C 23/0408 340/457
2006/0145829 A1* 7/2006 Watabe B60C 23/0408 340/447
2006/0148456 A1 7/2006 Chuey
2006/0152342 A1 7/2006 Turner et al.
2006/0161327 A1 7/2006 Emmerich et al.
2006/0187014 A1 8/2006 Li et al.
2006/0192661 A1 8/2006 Gerardiere
2006/0201241 A1* 9/2006 Durif B60C 23/0493 73/146
2006/0217850 A1 9/2006 Geerlings et al.
2006/0235641 A1 10/2006 Fink et al.
2006/0273889 A1 12/2006 Schulze et al.
2007/0063814 A1 3/2007 Olson et al.
2007/0069947 A1 3/2007 Banet et al.
2007/0090936 A1 4/2007 Nornes
2007/0176736 A1 8/2007 Chuey et al.
2007/0182531 A1* 8/2007 Kuchler G07C 5/085 340/438
2007/0190993 A1 8/2007 Chuey et al.
2007/0194898 A1 8/2007 Fukumori
2007/0210920 A1* 9/2007 Panotopoulos G06L 19/0705 340/572.1
2007/0213951 A1 9/2007 Van Eeden
2007/0223484 A1* 9/2007 Crowle H04J 3/0664 370/394
2007/0247294 A1 10/2007 Baader et al.
2007/0279201 A1 12/2007 Casey et al.
2008/0001729 A1 1/2008 Kyllmann et al.
2008/0024287 A1 1/2008 Boyle et al.
2008/0037458 A1 2/2008 Myszne
2008/0062880 A1 3/2008 Yew et al.
2008/0080447 A1 4/2008 Grube et al.
2008/0094198 A1 4/2008 Yu
2008/0100430 A1 5/2008 Kochie et al.
2008/0141766 A1 6/2008 Roth et al.
2008/0143593 A1 6/2008 Graziano et al.
2008/0157954 A1 7/2008 Tsuchida
2008/0165688 A1 7/2008 Beshai et al.
2008/0173082 A1 7/2008 Hettle et al.
2008/0177441 A1 7/2008 Marlett et al.
2008/0204217 A1 8/2008 Costello et al.
2008/0205553 A1* 8/2008 Costello B60C 23/0408 375/316
2008/0211672 A1* 9/2008 Pei G01S 13/825 340/572.1
2008/0240283 A1* 10/2008 Iwamura G08C 23/04 375/295
2008/0256260 A1 10/2008 Magnusson et al.
2008/0282965 A1 11/2008 Crano
2008/0285507 A1 11/2008 Mukherjee et al.
2008/0320243 A1 12/2008 Mitsuzuka et al.
2009/0033478 A1 2/2009 Deniau et al.
2009/0045930 A1* 2/2009 Fu B60T 17/18 340/447
2009/0067854 A1 3/2009 Yokogawa et al.
2009/0070863 A1 3/2009 Shimizu et al.
2009/0108992 A1 4/2009 Shafer
2009/0179747 A1* 7/2009 Lin B60C 23/0433 340/442
2009/0184815 A1* 7/2009 Suzuki B60C 23/0408 340/447
2009/0207859 A1 8/2009 Beshai et al.
2009/0231114 A1 9/2009 Yu
2009/0245803 A1 10/2009 Garner et al.
2009/0267751 A1 10/2009 Kaleal
2009/0291710 A1 11/2009 Jheng et al.
2009/0310477 A1* 12/2009 Lee H04L 5/0007 370/208
2010/0071453 A1 3/2010 Isono
2010/0308987 A1 12/2010 Haas et al.
2011/0140876 A1 6/2011 Deniau
2011/0181321 A1* 7/2011 Matsudera H03K 5/24 327/65
2011/0211414 A1* 9/2011 Musha G11C 8/14 365/230.03
2011/0250860 A1 10/2011 Lin
2011/0267024 A1* 11/2011 Halberstadt H02M 3/156 323/304
2011/0294548 A1 12/2011 Jheng et al.
2012/0001745 A1 1/2012 Li
2012/0117788 A1 5/2012 Deniau
2012/0119895 A1 5/2012 Deniau
2012/0147184 A1* 6/2012 Siann H04N 7/185 348/143
2012/0185110 A1 7/2012 Deniau et al.
2012/0274461 A1 11/2012 Colombo et al.

FOREIGN PATENT DOCUMENTS

DE 19720123 7/1998
DE 19924830 11/2000
DE 10014076 10/2001
DE 10040238 3/2002
DE 10247761 6/2003
DE 10217239 7/2003
DE 10207014 8/2003
DE 10307265 10/2003
DE 69529456 11/2003
DE 10247149 4/2004
DE 60108973 7/2005
DE 60202342 12/2005
DE 60023387 7/2006
DE 102005004825 8/2006
DE 102005059009 6/2007
DE 102007039599 3/2008
DE 102008008237 8/2009
DE 102008033051 2/2010
DE 102008033051 A1 * 2/2010 .... G01S 5/0027
EP 793579 9/1997
EP 1026016 8/2000
EP 1291230 3/2003
EP 1428694 A2 12/2003
EP 1440824 A2 7/2004
EP 1494877 1/2005
EP 1536392 A1 6/2005
EP 1547827 6/2005
EP 1562162 8/2005
EP 1026015 5/2006
EP 1674299 A2 6/2006
EP 1352763 4/2008
EP 1340629 6/2008
GB 2387032 10/2003
GB 2420415 5/2006
JP 62003537 1/1987
JP 63090407 A 4/1988
JP 05107134 4/1993
JP 8244423 9/1996
JP 2000142044 5/2000
JP 2000238515 9/2000
JP 2001080321 3/2001
JP 2001312860 A 9/2001
JP 2003025817 1/2003
JP 2003-312220 11/2003
JP 2004-145474 5/2004
JP 2005289116 10/2005
JP 2006015832 1/2006
JP 2007010427 A 1/2007
JP 2007200081 8/2007
JP 2007283816 11/2007
JP 2007283816 A * 11/2007
JP 2008137585 6/2008
JP 4265448 B2 2/2009
JP 5502729 B2 5/2014
KR 2003068216 8/2003
KR 1020070040883 A 4/2007
KR 10-2009-0091001 8/2009
RU 38461 U1 6/2004
RU 2238190 10/2004
RU 2398680 C2 6/2006
RU 2409480 C2 7/2006

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

RU	2352473	C1	4/2009
WO	9420317		9/1994
WO	9422693		10/1994
WO	9908887		2/1999
WO	0072463		11/2000
WO	0145967		6/2001
WO	02094588		11/2002
WO	03016079		2/2003
WO	2004038674		5/2004
WO	2005085651		9/2005
WO	2005116603		12/2005
WO	2007/006871	A1	1/2007
WO	2008-103973	A1	8/2008
WO	2008106387		9/2008
WO	2008107430		9/2008
WO	2009006518		1/2009
WO	2012/097154	A1	7/2012
WO	2015/015692	A1	2/2015

OTHER PUBLICATIONS

"Philips Magnavox 4 Function with Back Lighted Keypad Universal Remote" Operating Instructions, printed Oct. 2012, Philips Electronics North America Corporation.

"RadioShack 8-in-One Touch Screen Remote Control", Owner's Manual, 2001, RadioShack Corporation.

KAIS MNIF, "A Smart Tire Pressure Monitoring System", Sensors Magazine, Nov. 1, 2001.

International Search Report and Written Opinion dated Sep. 28, 2012, from corresponding International Patent Application No. PCT/US2011/047112.

International Search Report dated Apr. 6, 2012, from corresponding International Patent Application No. PCT/US2011/047087.

International Search Report and Written Opinion mailed on Oct. 15, 2008, for Application No. PCT/US2008/069006.

International Preliminary Report on Patentability mailed on Jan. 14, 2010, for Application No. PCT/US2008/069006.

Chinese Office Action mailed on Apr. 19, 2011, for Chinese Application 200880023390.7 (Corresponding to PCT/US2008/069006).

Chinese Office Action (second) mailed on Feb. 16, 2012, for Chinese Application 200880023390.7 (Corresponding to PCT/US2008/069006).

Chinese Office Action (third) mailed on Oct. 10, 2012, for Chinese Application 200880023390.7 (Corresponding to PCT/US2008/069006).

Japanese Office Action mailed on Jun. 7, 2012, for JP Application 2010-515252 (Corresponding to PCT/US2008/069006).

International Search Report and Written Opinion dated Sep. 28, 2012, from corresponding International Patent Application No. PCT/US2011/047104.

Germany Office Action dated Nov. 19, 2012.

Germany Office Action dated Sep. 17, 2007.

Preliminary Invalidity Contentions of Defendant Continental Automotive Systems US, Inc.; dated Jan. 17, 2012, In the United States District Court for Western District of Virginia Lynchburg Division, Civil Action No. 6:11-CV-00014-NKM.

Amended Invalidity Contentions of Defendant Continental Automotive Systems US, Inc.; dated Jun. 18, 2012, , In the United States District Court for Eastern District of Michigan Southern Division, Civil Action No. 2:12-cv-10715-SJM-MJH.

Plaintiffs' Initial Infringement Contentions; dated Dec. 15, 2011, In The United States District Court for Western District of Virginia Lynchburg Division, Civil Action No. 6:11-CV-00014-NKM-RSB.

Joint Claim Construction and Prehearing Statement, dated Jun. 11, 2012, from co-pending litigation: *Schrader-Bridgeport Int'l, Inc.* v. *Continental Automotive Sys, US, Inc.*, case docket No. 2:12-cv-10715-SJM-MJH, (filed Feb. 16, 2012, E.D. Mich.).

Plaintiffs' Opening Claim Construction Brief, dated Jun. 26, 2012, from co-pending litigation: *Schrader-Bridgeport Int'l, Inc.* v. *Continental Automotive Sys. US, Inc.*, case docket No. 2:12-cv-10715-SJM-MJH, (filed Feb. 16, 2012, E.D. Mich.).

USPTO Translation of JP2003025817A, translated from Japanese by Schreiber Translations, Inc., Feb. 2013.

Jeff Burgess, "TPMS Demonstration Kit", AN1943/D, Rev 1, Apr. 2002, Motorola, Inc., 2002 (16 pgs.).

International Search Report and Written Opinion dated Sep. 28, 2012, from corresponding International Patent Application No. PCT/US2011/047108.

Jeff Burgess, "Tire Pressure Monitoring System Reference Design", Tire Pressure Monitor System Demo, AN1951/D, Rev 1, May 2003, Motorola, Inc., 2003 (24 pgs.).

"Motorola's MPXY8000 Series Tire Pressure Monitoring Sensors", Motorola Sensor Products Division Transportation & Standard Products Group, Motorola, Inc., May 2003 (22 pgs.).

Alfred Pohl et al. "Wirelessly Interrogable Surface Acoustic Wave Sensors for Vehicular Applications", IEEE Transactions on Instrumentation and Measurement vol. 46, No. 4, IEEE, Aug. 1997 (8 pgs.).

"Tire pressure Warning System Using Direct Measurement Method (SOARER)" G0880A ISSN: 0388-3841, vol. 51 No. 7, pp. 174-179, Toyota Motor Corporation, May 2, 2002 (6 pgs.).

Search Report dated Jun. 20, 2014, from EP Patent Application No. 11870613.4.

Search Report dated Jun. 30, 2014, from EP Patent Application No. 11870701.7.

Search Report dated Mar. 24, 2015, from EP Patent Application No. 11870650.6.

Search Report dated Apr. 19, 2012, from International Patent Application No. PCT/US2012/021082.

Search Report dated Aug. 20, 2015, from GB Patent Application No. GB1503824.3.

Machine Translation of RU2423246 C1.

Translation of Abstract of KR1020070040883A.

* cited by examiner

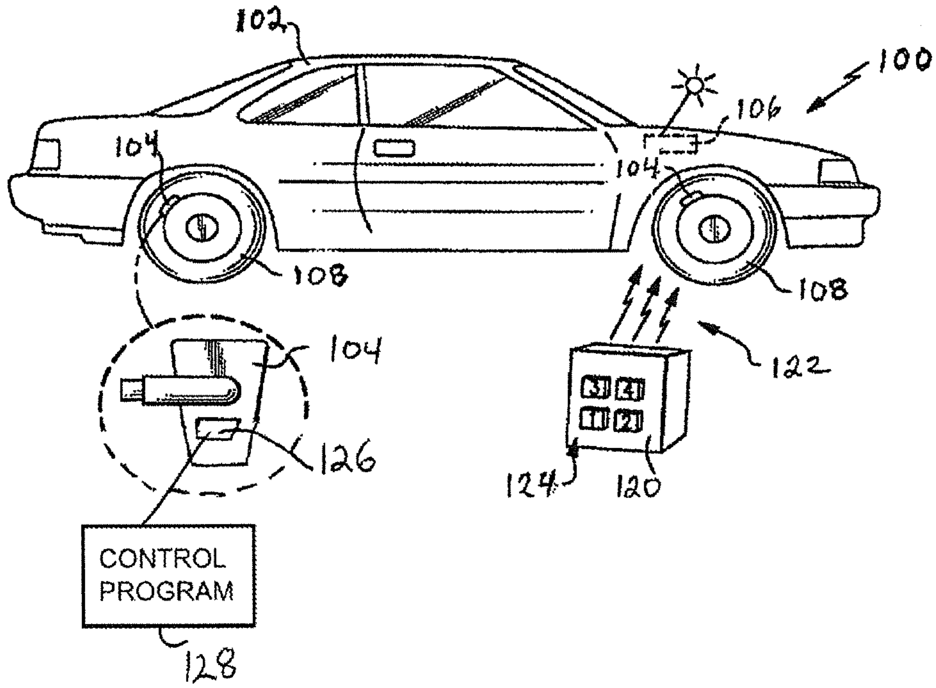

102
100
106
104
104
108
108
104
122
126
124
120
CONTROL PROGRAM
128

FIG.1

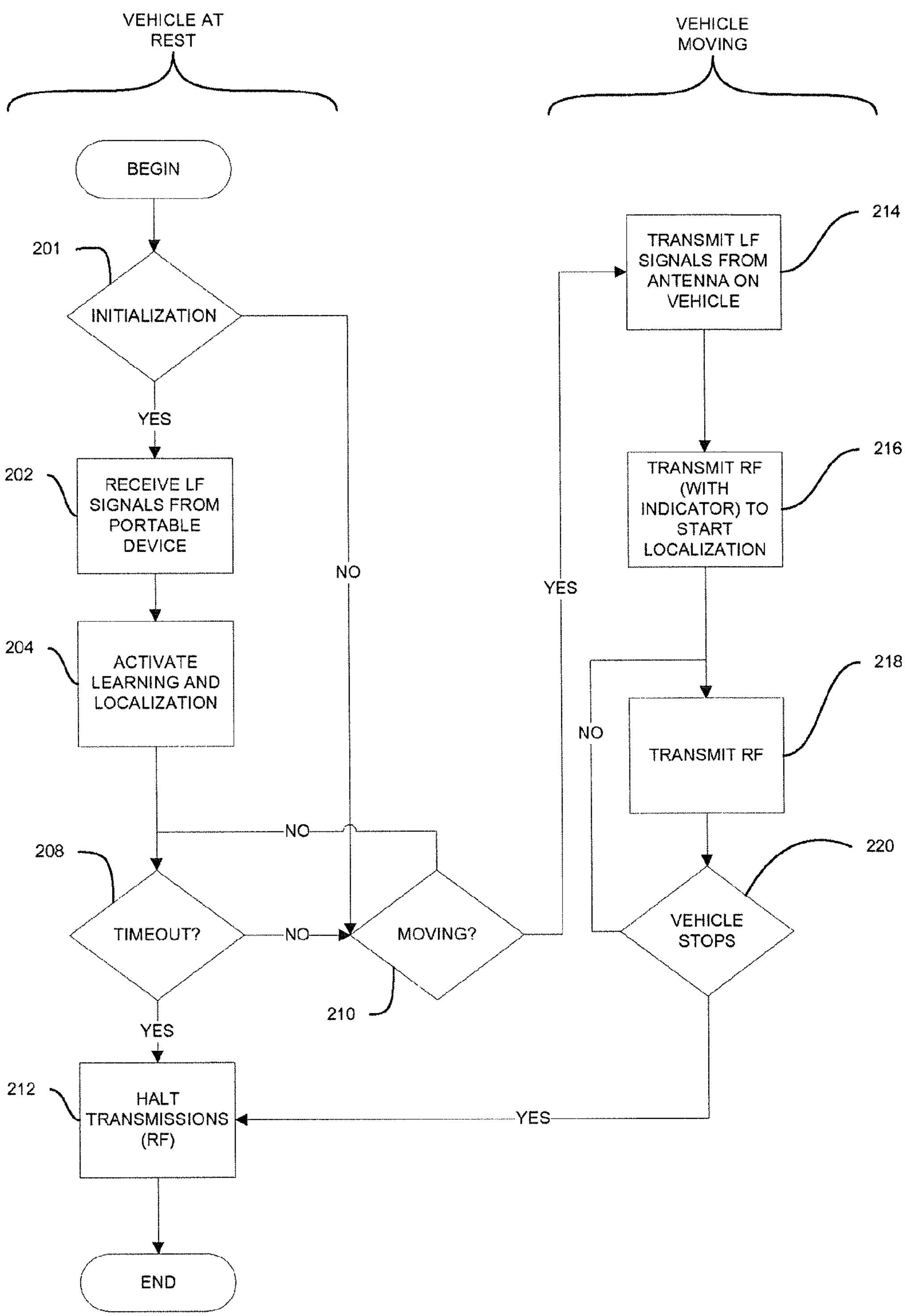

VEHICLE AT REST
VEHICLE MOVING
BEGIN
201
INITIALIZATION
YES
NO
202
RECEIVE LF SIGNALS FROM PORTABLE DEVICE
204
ACTIVATE LEARNING AND LOCALIZATION
208
TIMEOUT?
NO
NO
210
MOVING?
YES
212
HALT TRANSMISSIONS (RF)
END
214
TRANSMIT LF SIGNALS FROM ANTENNA ON VEHICLE
216
TRANSMIT RF (WITH INDICATOR) TO START LOCALIZATION
218
TRANSMIT RF
NO
220
VEHICLE STOPS
YES
YES

Fig. 2

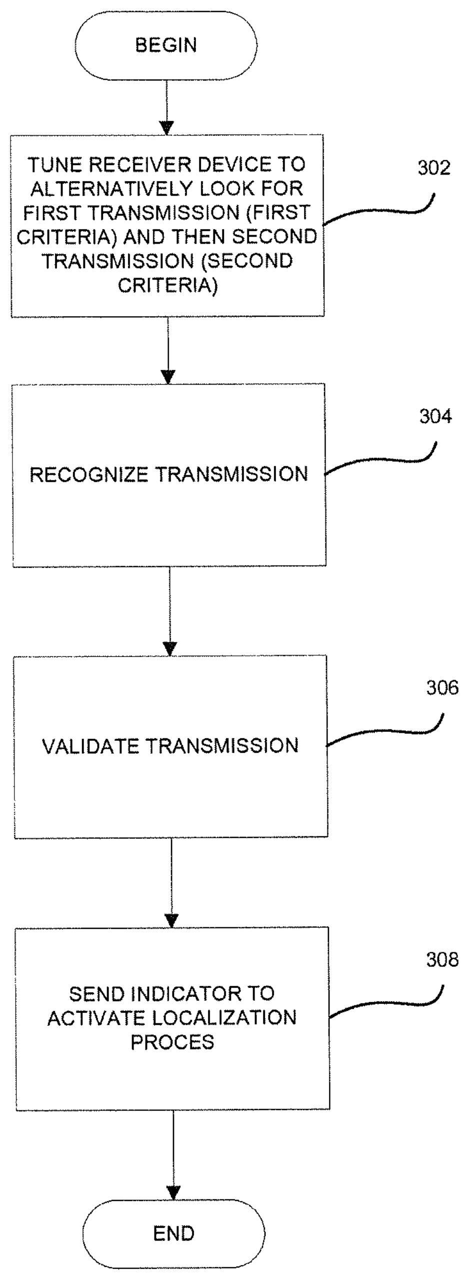

BEGIN
TUNE RECEIVER DEVICE TO ALTERNATIVELY LOOK FOR FIRST TRANSMISSION (FIRST CRITERIA) AND THEN SECOND TRANSMISSION (SECOND CRITERIA)
302
RECOGNIZE TRANSMISSION
304
VALIDATE TRANSMISSION
306
SEND INDICATOR TO ACTIVATE LOCALIZATION PROCES
308
END

Fig. 3

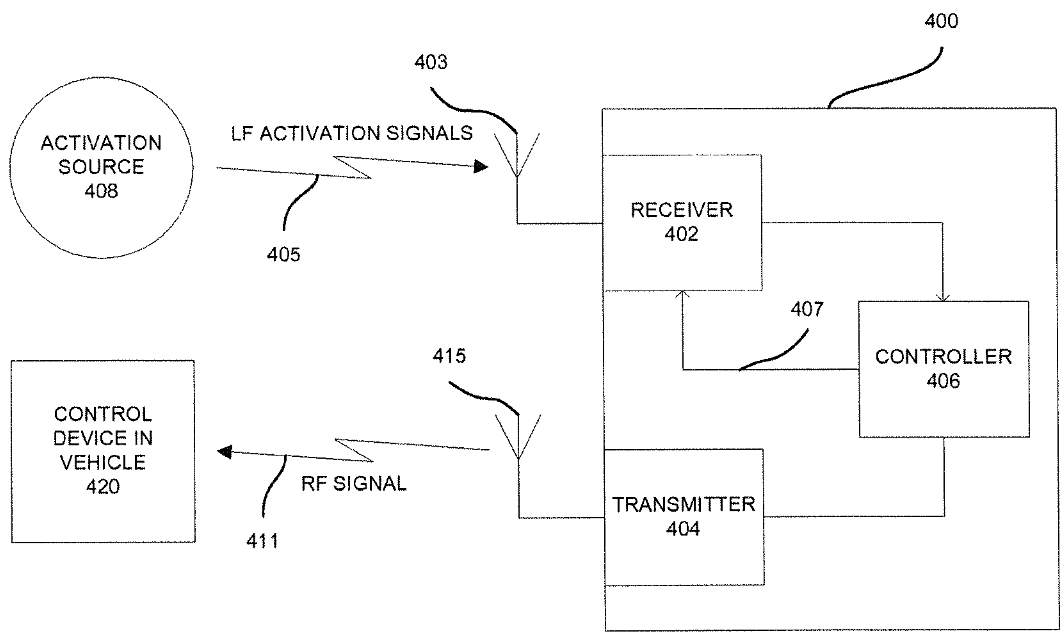

400
403
LF ACTIVATION SIGNALS
ACTIVATION SOURCE 408
405
RECEIVER 402
407
CONTROLLER 406
415
CONTROL DEVICE IN VEHICLE 420
RF SIGNAL
411
TRANSMITTER 404

Fig. 4

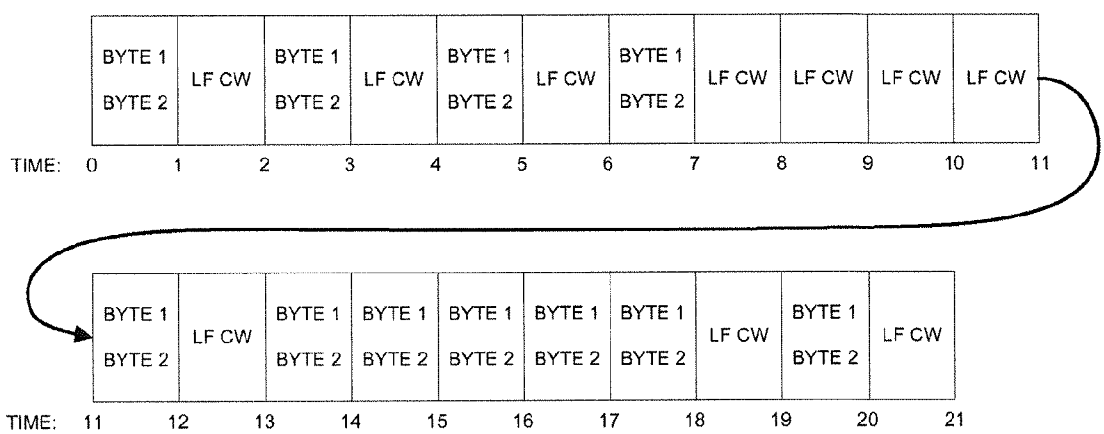

BYTE 1
BYTE 2
LF CW
BYTE 1
BYTE 2
LF CW
BYTE 1
BYTE 2
LF CW
BYTE 1
BYTE 2
LF CW
LF CW
LF CW
LF CW
TIME: 0 1 2 3 4 5 6 7 8 9 10 11
BYTE 1
BYTE 2
LF CW
BYTE 1
BYTE 2
BYTE 1
BYTE 2
BYTE 1
BYTE 2
BYTE 1
BYTE 2
BYTE 1
BYTE 2
LF CW
BYTE 1
BYTE 2
LF CW
TIME: 11 12 13 14 15 16 17 18 19 20 21

Fig. 5

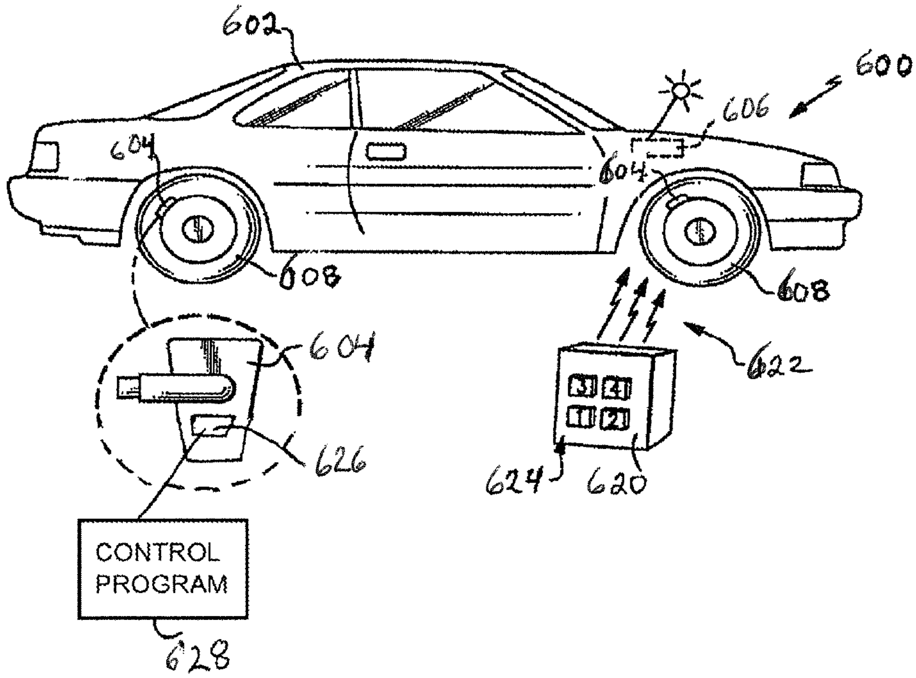

602
600
606
604
604
608
608
604
622
626
624
620
CONTROL PROGRAM
628
1
2
3
4

FIG. 6

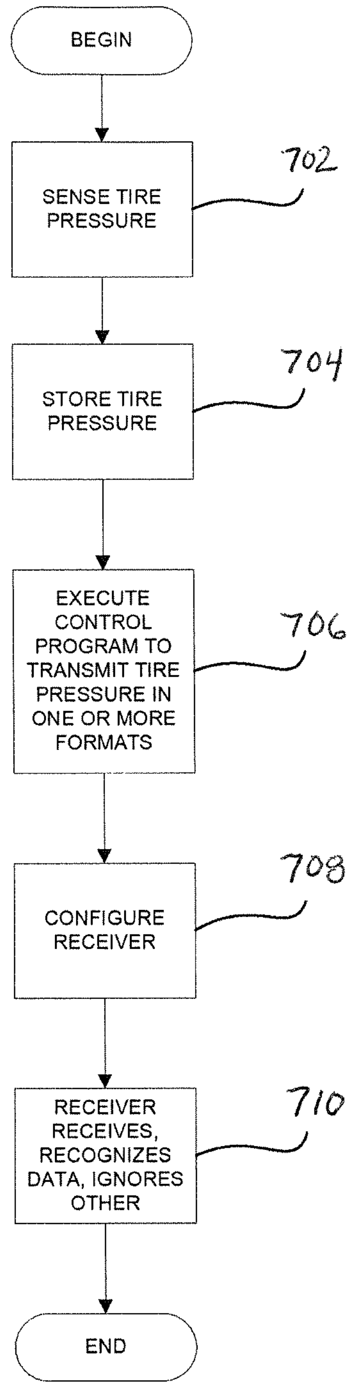

BEGIN
SENSE TIRE PRESSURE
702
STORE TIRE PRESSURE
704
EXECUTE CONTROL PROGRAM TO TRANSMIT TIRE PRESSURE IN ONE OR MORE FORMATS
706
CONFIGURE RECEIVER
708
RECEIVER RECEIVES, RECOGNIZES DATA, IGNORES OTHER
710
END

Fig. 7

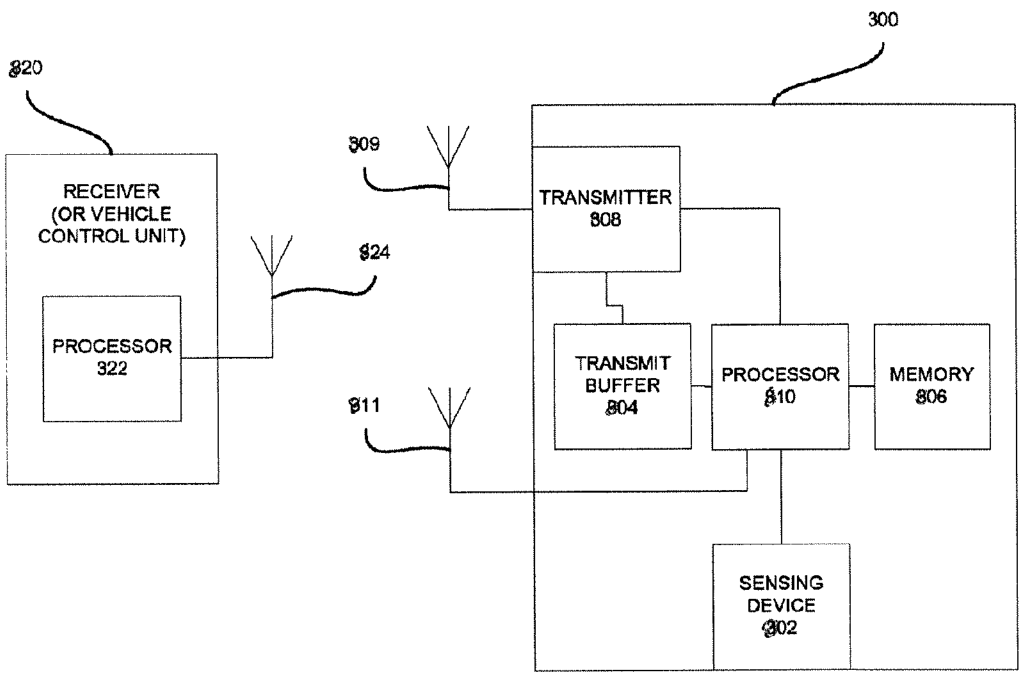

300
320
RECEIVER
(OR VEHICLE
CONTROL UNIT)
PROCESSOR
322
324
309
TRANSMITTER
308
TRANSMIT
BUFFER
304
PROCESSOR
310
MEMORY
306
311
SENSING
DEVICE
302

Fig. 8

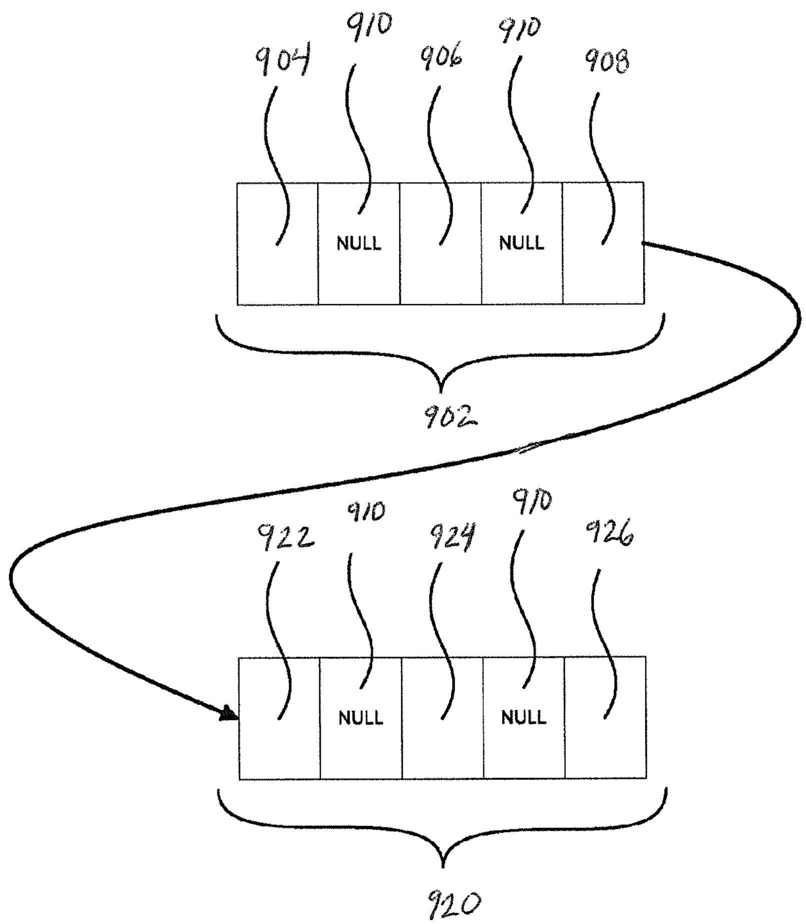

910
910
904
906
908
NULL
NULL
902
910
910
922
924
926
NULL
NULL
920

Fig. 9

BURST 1

M1-F2	P1	M2	P2	M1-F2	P3	M3-F1	P4	M4-F1	P5	M4-F2	P6	M1-F2

BURST 2

M1-F1	P7	M3-F2	P8	M1-F1	P9	M4-F1	P10	M1-F1	P11	M4-F2	P12	M1-F1

BURST 3

M1-F3	P13	M2	P14	M1-F3	P15	M3-F1	P16	M4-F1	P17	M4-F2	P18	M1-F3

BURST 4

M1-F2	P19	M3-F2	P20	M1-F2	P21	M4-F1	P22	M1-F2	P23	M4-F2	P24	M1-F2

BURST 5

M1-F1	P25	M2	P26	M1-F1	P27	M3-F1	P28	M4-F1	P29	M4-F2	P30	M1-F1

BURST 6

M1-F3	P31	M3-F2	P32	M1-F3	P33	M4-F1	P34	M1-F3	P35	M4-F2	P36	M1-F3

M1-F1 = Manufacturer 1, Format 1
M1-F2 = Manufacturer 1, Format 2
M1-F3 = Manufacturer 1, Format 3
M2 = Manufacturer 2
M3-F1 = Manufacturer 3, Format 1
M3-F2 = Manufacturer 3, Format 2
M4-F1 = Manufacturer 4, Format 1
M4-F2 = Manufacturer 4, Format 2
Pn = Pause

Fig. 10

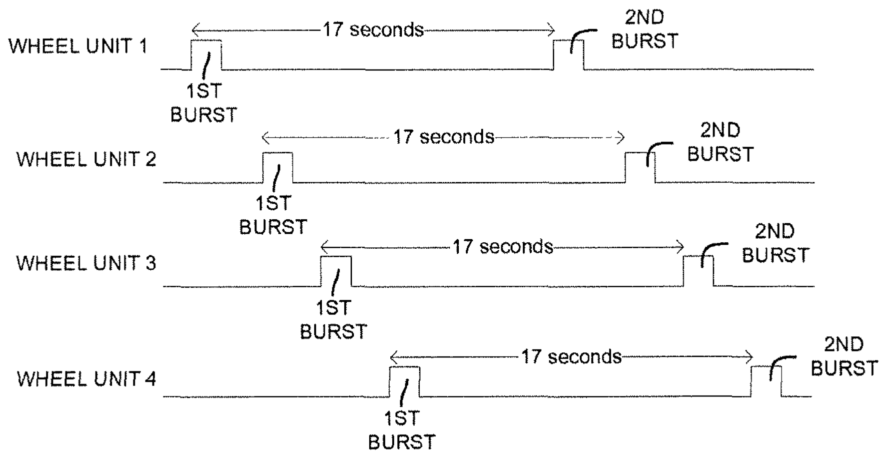

WHEEL UNIT 1
17 seconds
1ST
BURST
2ND
BURST
WHEEL UNIT 2
17 seconds
1ST
BURST
2ND
BURST
WHEEL UNIT 3
17 seconds
1ST
BURST
2ND
BURST
WHEEL UNIT 4
17 seconds
1ST
BURST
2ND
BURST

Fig. 11

APPARATUS AND METHOD FOR DATA TRANSMISSIONS IN A TIRE PRESSURE MONITOR

CROSS REFERENCE TO RELATED APPLICATIONS

This patent is a continuation of US application 20130038442 entitled "Apparatus and Method for Activating a Localization Process for a Tire pressure Monitor," the disclosure of which is incorporated herein by reference in its entirety. This patent also incorporates herein by reference in their entirety the disclosures of US application 20130038441 entitled "Protocol Arrangement in a Tire Pressure Monitoring System", US application 20130038443 entitled "Protocol Misinterpretation Avoidance Apparatus and Method for a Tire Pressure Monitoring System", and US application 20130038440 entitled "Tire Pressure Monitoring Apparatus and Method".

TECHNICAL FIELD

The technical field relates to tire pressure monitoring devices that utilize potentially different transmission protocols.

BACKGROUND

The pressure and other operating parameters of tires are important concerns when operating a vehicle. Not only can incorrect tire pressure (or the incorrect setting of some other tire parameter) lead to inefficient vehicle operation (e.g., the waste of fuel and other problems leading to higher operating costs), but too low a tire pressure (or an inadequate value for some other tire parameter) can lead to safety problems such as accidents. It is difficult and sometimes time-consuming for users to manually measure tire pressure (or other parameters) with a pressure gauge (or other instruments). Consequently, automatic tire pressure monitoring systems have been devised and these systems free the user from manually making tire measurements.

An automatic tire pressure monitoring device typically mounts to a wheel within the tire and wirelessly transmits information indicative of conditions within the tire. The transmissions and the order of information are typically defined by a protocol corresponding to a receiver within the vehicle. Once the receiver receives the information, the information can be processed and presented to a user. For instance, a user can be warned when the pressure in the tires is too high or too low and thus avoid safety problems. Each automobile manufacturer typically has a unique, preferred, and pre-defined protocol to meet application specific needs and applications. Consequently, receivers using one manufacturers' protocol are not responsive to transmitters operating according to other manufacturers' protocols.

Tire pressure monitors also typically need to be activated and/or initialized. Various portable tools can be used for this purpose. Unfortunately, a particular type of tire pressure monitoring device needs to operate with a tool that is compatible with that device. A user has to ensure that the two devices are compatible, or the tire pressure monitor cannot be initialized and/or activated. Consequently, a user needs to worry about compatibility issues and under some circumstances (e.g., when a mismatch is made by the user) the tire pressure monitor cannot be initialized. This results in user dissatisfaction with these previous approaches.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** comprises a block diagram of a tire pressure monitoring system according to various embodiments of the present invention;

FIG. **2** comprises a flowchart showing one example of an approach for initializing and/or activating a tire pressure monitor according to various embodiments of the present invention;

FIG. **3** comprises a flowchart showing one example of an approach for initializing and/or activating a tire pressure monitor according to various embodiments of the present invention;

FIG. **4** comprises a block diagram of a tire monitor according to various embodiments of the present invention;

FIG. **5** comprises a block diagram of timeline showing sensing patterns for a receiver device according to various embodiments of the present invention;

FIG. **6** comprises a block diagram of a tire pressure monitoring system according to various embodiments of the present invention;

FIG. **7** comprises a flowchart showing one example of an approach for monitoring pressure and/or other parameters of a tire according to various embodiments of the present invention;

FIG. **8** comprises a block diagram of another example of a tire pressure monitoring system according to various embodiments of the present invention;

FIG. **9** comprises a block diagram of transmission burst formats according to various embodiments of the present invention;

FIG. **10** comprises a block diagram of a burst diagram showing protocol arrangement according to various embodiments of the present invention;

FIG. **11** comprises a timing diagram for signals sent from the various wheel units of a vehicle according to various embodiments of the present invention.

Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions and/or relative positioning of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of various embodiments of the present invention. Also, common but well-understood elements that are useful or necessary in a commercially feasible embodiment are often not depicted in order to facilitate a less obstructed view of these various embodiments of the present invention. It will further be appreciated that certain actions and/or steps may be described or depicted in a particular order of occurrence while those skilled in the art will understand that such specificity with respect to sequence is not actually required. It will also be understood that the terms and expressions used herein have the ordinary meaning as is accorded to such terms and expressions with respect to their corresponding respective areas of inquiry and study except where specific meanings have otherwise been set forth herein.

DETAILED DESCRIPTION

Approaches are provided where a tire pressure monitoring device can receive and recognize activation signals from a plurality of activation sources, each of these sources potentially transmitting according to different formats, different data contents, and/or different protocols. Consequently, according to the present approaches a user does not have to ensure that a particular activation device is compatible with a particular tire pressure monitor. In fact, the user can simply install the tire pressure monitor described herein and activate the device without worrying about compatibility. In one aspect, the approaches described herein can achieve compatibility in the sense that all activation devices can be accommodated. In another aspect, a subset of all possible activation devices can be accommodated, such as the most popular devices to mention one example. By "activation" and as used herein it is meant that a process is executed upon the tire pressure monitor being "activated." For example, a localization process can be executed. In another example, a control program that transmits RF frames can be executed. Other examples are possible.

In many of these embodiments, a receiver device is tuned to monitor first transmissions at a first time according to a first criterion and to monitor transmissions at a second time according to a second criterion. When the receiver device initially recognizes one of the first transmissions being transmitted according to the first criterion or the second transmissions being transmitted according to the second criterion, the recognized transmission is verified as being valid or authentic. When the transmission is recognized as valid or authentic, an indication is sent to a receiver (e.g., a control unit in a vehicle) and this is effective to activate a localization process that in turn ensures that tire pressure monitoring information can be correlated to a particular tire (with a known identifier) at a known location.

In one aspect, the first criterion describes a low frequency (LF) sinusoidal waveform and the second criterion describes a low frequency (LF) transmission of a predetermined data pattern. Other examples are possible. In another aspect, the verifying includes verifying that the recognized transmission is received for a predetermined time period.

In other aspects, the sensitivity of the receiver device in the monitor can be dynamically adjusted. For example, it can be lowered when the vehicle is not moving and increased when the vehicle is moving.

The transmission of the tire pressure information may be accomplished in a variety of different ways. For instance, a control program may be executed to transmit the tire pressure information according to each of a plurality of communications formats incorporated into the control program and not according to a manufacturers' code. Transmissions may be made according to each and every possible manufacturers' protocol or a subset of these protocols. Other examples of transmission approaches are possible.

In others of these embodiments, an apparatus (e.g., a tire pressure monitor) includes a receiver device, a transmitter apparatus, and a controller. The receiver device is configured to receive first transmission and second transmissions from an activation source or sources.

The controller is coupled to the transmitter apparatus and the receiver device. The controller is configured to tune the receiver device to monitor first transmissions at a first time according to a first criterion and to monitor transmissions at a second time according to a second criteria. The controller is further configured to when the receiver device initially recognizes one of the first transmissions being transmitted according to the first criterion or the second transmissions being transmitted according to the second criterion, to verify that the recognized transmission is valid. The controller is still further configured to when the transmission is recognized as valid, send an indication to a receiver so that a localization process can be accomplished. Once the localization process is accomplished, tire pressure information that is sent can be associated with a monitor at a known location.

Thus, approaches are provided where a tire pressure monitoring device can receive and recognize activation signals from a plurality of sources, each of these sources potentially transmitting according to different formats, different data contents, and/or different protocols. Consequently, according to the present approaches a user does not have to ensure that a particular activation device is compatible with a particular tire pressure monitor and the user can simply install the monitor and automatically activate the localization process associated with the device without concerns about compatibility.

Referring to FIG. **1**, a tire pressure monitoring system **100** is shown assembled within a vehicle **102**. The system **100** includes a receiver **106** that receives communications from tire pressure monitoring devices **104** ("monitors") assembled within each of the vehicle's tires **108**. The receiver **106** may be any communication device configured to receive any type of transmitted communication but tuned to only recognize some of these communications. In one example, these communications are radio frequency (RF) communications, but other types of communications are also possible.

Although the device **104** is described as a tire pressure monitoring device herein, it will be appreciated that this device can gather and transmit other types of information related to the tire in addition to or in place of tire pressure information. For example, the information can include temperature information, acceleration information, or information related to the wear of the treads of the tire. Appropriate sensors or sensing devices may be used to obtain this information. Other examples of information may also be gathered by the tire pressure monitoring device **104**.

Each of the tire pressure monitoring devices **104** are assembled within the tires **108** of the vehicle **102** and, as mentioned, communicate information indicative of conditions within the tires **108** to the receiver **106**. These conditions include temperature, pressure, and/or any other desired information that aids in the evaluation of tire conditions. Other examples of conditions may also be sensed.

The system **100** includes the tire pressure monitoring devices **104** that in this example includes a memory device **126**. The memory device **126** is utilized for the storage of a control program **128**. The control program **128**, once compiled and executed, transmits sensed information (e.g., tire pressure information) according to one or more protocols (or formats) that govern operation and communication between the tire pressure monitoring device **104** and the receiver **106**. Examples of communication protocols that may be used include protocols that specify the frequency and timing of transmissions from the tire pressure monitoring device **104** to the receiver **106** or the format of transmission (such as what constitutes a "1" or a "0," modulation type, error detection and/or correction content, synchronization pattern, and so forth to name but a few examples in these regards). Tire pressure monitoring information may be transmitted according to the protocols sequentially (e.g., using the same antenna) or at the same time (e.g., using different antennas). No separate manufacturers' codes are used in making the transmissions. Once the control program is compiled, the protocols that have been selected cannot be changed without changing (e.g., editing, compiling, and installing anew) the control program **128**. In one aspect, the control program **128** is compiled and stored in the memory **126** during manufacturing.

In one aspect, the control program **128** may be executed continuously whenever the vehicle is moving. The control program **128** may also be executed when the vehicle is not moving, but only when the sensor is activated externally (i.e., via LF or grounding of a pin on the ASIC during manufacturing). At other times, it may not be executed. However, learning the identities of the devices **104** and/or determining where each device is located ("localization", e.g., front left, front right, and so forth) may be accomplished by using an activation device **120**. The activation device **120** emits a wireless signal **122** (e.g., an LF signal) that is received by a corresponding one of the tire pressure monitoring devices **104**. Receipt of the wireless signal **122** causes the device **104** to transmit identity information and also indicate to the receiver **106** that the device **104** has received an LF signal and that the localization process can occur. When the vehicle is moving, LF transmitters (e.g., antennas) may transmit LF signals (in place of the device **120**). When moving, the RF signals are periodically being transmitted and when the device **104** finds an LF signal, it so indicates to the receiver **106** (e.g., by flipping a bit in the RF transmission). Once this indication is received, localization can be completed (e.g., this process may occur for a predetermined amount of time to ensure that the device **104** is correctly localized). Once localization is complete, tire pressure information can be associated with a known tire. It will be appreciated that in other examples, the control program may itself be activated by the LF signals.

The activation device **120** includes a series of selectable buttons **124** (or other types of actuators) that are actuated by a user to indicate that they wish to activate the tire pressure monitoring device. Although the example device **120** is shown with buttons, other display and selection configurations, such as touch screens, switches or some other selection interface may be used as will be appreciated by those skilled in the art. Accordingly, installation of the multi-application tire pressure monitoring devices **104** optionally includes the initial step of physically activating the tire pressure monitoring devices **104** within each of the corresponding tires **108** or activate a localization process that allows tire pressure data to be associated with particular tires.

If an activation device is used, the activation device **120** is placed proximate to each of the tire pressure monitoring devices **104** to send a signal **122**. In one example, the signal **122** is a low frequency transmission received by the proximate tire pressure monitoring device **104**.

The devices **104** operate with the receiver **106** in the vehicle and the receiver **106** typically has a display (or some sort of user interface) that is configured to alert the driver when the tire pressure falls below a predetermined threshold value. As mentioned, once physically installed in the tire, the devices **104** are first "learned" by the control unit. During this process, the receiver **106** determines the particular identifiers and during or after learning, a localization process may be executed in which each of the devices **104** is associated with a particular tire.

During normal operation (after the sensors are learned and localized and the vehicle is moving), the device **104** senses the tire pressure and sends a radio frequency (RF) signal to the receiver **106** indicating the tire pressure. The receiver **106** can then determine if a pressure problem exists. If a problem exists, the user can be alerted so that appropriate action can be taken. As mentioned, this is all accomplished by use of a control program that is compiled, translated, and/or assembled before it is executed. In one aspect, once compiled the structure of the control program (e.g., the protocols selected) cannot be changed. Also, nothing external to the device can be input into this control program to change the structure of the control program once the control program (and the protocols specified in the control program) is compiled. It will be appreciated that although many of the examples described herein refer to a control program being executed to transmit RF frames with tire pressure information, that other approaches can also be used. For instance, systems that utilize manufacturers' codes can also have their monitors localized according to the approaches described herein.

The devices **104** can also receive indications as to whether the vehicle is moving. For example, a signal can be sent from the control unit of the vehicle with this information.

Referring now to FIG. **2**, one example of an approach for operating a tire pressure monitoring system is described. At step **201**, it is determined if the user is attempting to initialize the sensor. If the answer is affirmative, step **202** is performed and if the answer is negative, step **210** is performed. At step **202**, LF signals are received from an external activation source. The external source may be a portable or fixed device. The received signals may be sinusoidal signals of a predetermined frequency (CW) or be modulated to include information (e.g., bytes of information). Signals other that LF signals may also be used. The device verifies that the signals are what was expected. When verified, an indicator is transmitted to a receiver (e.g., a control module) that informs the receiver that the monitor has received and verified LF reception.

In another aspect, the type of signals received may affect the operation of the monitor. For instance if LF CW signals are received, bursts have certain formats may be sent. Other examples are possible.

At step **204** and upon verification, the learning process and localization process are performed. Learning refers to obtaining the identifier of a monitor and localization refers to determining where the monitor is located (e.g., front right wheel, front left wheel and so forth). The indicator transmitted by the monitor may be an RF signal of a burst of frames whereby selected ones of the frames include tire pressure information and where a specified predetermined bit is flipped (from a "0" to a "1", or vice versa) to indicate LF was verified at the monitor. It will be appreciated that the monitor may attempt to verify reception of LF signals a predetermined number of times to ensure that the signal is valid.

At step **208** it is determined if a timeout has occurs (e.g., has a certain period of time passed so that RF transmissions can be halted). If the answer is affirmative, at step **212** transmissions are halted. If the answer is negative, execution continues at step **210** where it is determined whether the vehicle is moving.

If the answer at step **210** is negative, execution continues at step **208** as has been described above. If the answer is affirmative, then at step **214** LF signals are received from LF antennas at the vehicle and are verified as being valid activation signals.

At step **216**, an indicator is sent to the receiver to indicate that the monitor has received valid LF signals and the localization process is activated at the receiver (e.g., the vehicle controller). At step **218**, the RF transmissions are made and tire pressure information can be associated with a particular monitor at a known location. At step **220**, it is determined if the vehicle is stopped, in one example if it has been stopped for a predetermined period of time (e.g., 15 minutes). If the answer is negative, execution continues at step **218** and if the answer is affirmative execution continues at step **212**.

Referring now to FIG. **3**, one approach for activating a tire pressure monitor is described. At step **302**, a receiver device is tuned to monitor first transmissions at a first time according to a first criterion and to monitor transmissions at a second time according to a second criterion. In one aspect, the first criterion describes a low frequency (LF) sinusoidal waveform and the second criterion describes a low frequency (LF) transmission of a predetermined data pattern. In another aspect, the verifying includes verifying that the recognized transmission is received for a predetermined time period.

At step **304**, when the receiver device initially recognizes one of the first transmissions being transmitted according to the first criterion or the second transmissions being transmitted according to the second criterion. At step **306**, the transmission is recognized as valid and at step **308** an indication is sent to the receiver that the monitor has received a valid LF activation signal and that the localization process can be executed.

After step **308** is accomplished, the tire pressure information can be associated with a known monitor that is at a known location. Consequently, reports can be generated to the user that alert the user when a tire becomes deflated, for example. It will be appreciated that in one aspect tire pressure information can be transmitted periodically when the vehicle is moving. However, it is only after localization is completed that this information can be linked with a monitor that resides at a known location. As used herein, "monitor" refers to the tire pressure monitor such as one of the devices **104** in FIG. **1** or the device **400** of FIG. **4**.

Referring now to FIG. **4**, an apparatus **400** (e.g., a tire pressure monitor) for initializing a tire pressure monitor includes a receiver device **402**, a transmitter apparatus **404**, and a controller **406**. The receiver device **402** is configured to monitor for first transmission and second transmissions having predetermined formats (that may be present in activation signals **405**) received from an activation source or sources **408** via the antenna **403**.

The controller **406** is coupled to the transmitter apparatus **404** and the receiver device **402**. The controller **406** is configured to tune the receiver device **402** using control signals **407** to monitor for first transmissions at a first time according to a first criterion and to monitor for second transmissions at a second time according to a second criterion. The controller **406** is further configured to when the receiver device **402** initially recognizes one of the first transmissions being transmitted according to the first criterion or the second transmissions being transmitted according to the second criterion, to verify that the recognized transmission is valid (e.g., it matches predetermined requirements such as being of a particular frequency, having a particular value, having a predetermined power level, and so forth). The controller **406** is still further configured to when the transmission is recognized as valid, activate the transmission apparatus **404** to transmit an indicator (e.g., a flipped bit in an RF signal **411**) via the antenna **415**. This information **411** is transmitted to a vehicle receiver or controller **420** where it may be further processed as described above to initiate the localization process. Although the device **400** may be periodically broadcasting tire pressure information when the vehicle is moving (e.g., in bursts of frames transmitted every approximately 17 seconds) it is only after the localization process is complete that the tire pressure information can be associated with a known tire.

In another aspect, the sensitivity of the LF reception by the receiver device can be adjusted, i.e., it has a dynamic sensitivity. For example, the sensitivity can be lowered when the vehicle is at rest. This may be done, for example, so that when the vehicle is stopped spurious LF signals (e.g., caused by other electronic devices) are not confused as being valid signals. The sensitivity can be increased when the vehicle is moving since there is less of a chance of detecting spurious signals when the vehicle is moving down a roadway.

Referring now to FIG. **5**, one example of how a receiver device (e.g., device **402** in FIG. **4**) in a monitor is tuned is described. FIG. **5** shows an x-axis that represents time and the time units are expressed in arbitrary units (0, 1 . . . 23). Each time period includes the criteria that a controller (e.g., controller **406** of FIG. **4**) has tuned a receiver device (e.g., device **402** of FIG. **4**) to listen. For example, between time 0 and 1, the receiver device in the monitor is tuned to listen for LF signals that have a data content of byte 1 and byte 2. Between time 1 and 2, the receiver device in the monitor is tuned to listen for a low frequency (LF) sinusoidal signal (CW). It will be appreciated that these are examples only and that other types of signals can be listened for and in different orders.

Between times 8 and 9, the controller identifies the received transmission as an LF CW transmission. Between time 9 and 12 the receiver device in the monitor is configured to verify this is a valid transmission by listening for the LF CW pattern. For example, the receiver device in the monitor ensures that this is not a noise signal by verifying a constant frequency and/or amplitude to take one example, At time 12, the transmission of RF signals (e.g., using a control program) is enabled. The receiver device in the monitor then alternates between checking/listening for the byte pattern and LF CW patterns described above.

At times 16 and 17, the controller identifies the received transmission as one of the byte patterns byte 1 or byte 2. Between time 17 and 20 the receiver is configured to verify this is a valid transmission by listening for byte 1 or byte 2. For example, the receiver device ensures that this is not a noise signal by verifying that the values of byte 1 or byte 2 do not change. At time 20, the transmission of RF signals (e.g., using a control program) is enabled. The receiver device then alternates between checking for the byte pattern and LF CW patterns described above.

It will be appreciated that in this example the LF CW may be transmitted by one type of activation device (e.g., from a first manufacturer) while the LF byte transmissions are transmitted by another type of activation device (e.g., from a second manufacturer). However, these approaches are applicable to any number of possible received formats and are not limited to two as shown here. The byte patterns may be any byte pattern as is known to those skilled in the art.

Approaches are provided wherein a burst of frames is sent from a tire pressure monitor to a receiver and this burst is constructed to successfully transmit the frames of various manufacturers and, at the same time, meet various criteria such as manufacturers' guidelines, government rules, system functionality, and noise avoidance. The approaches described herein allow the maximum amount of information to be effectively transmitted from the tire pressure monitor within the framework of various requirements. In so doing, an effective multi-application tire pressure monitoring device (e.g., that transmits frames according to the protocols of multiple manufacturers) is provided.

An apparatus for transmitting tire pressure signals includes a transmission buffer and a transmitter. The transmission buffer is configured to store tire pressure monitoring data. The transmitter is configured to transmit a signal including the tire pressure monitoring data. The signal includes a burst that includes plurality of frames and each of the frames includes the tire pressure monitoring information. A plurality of pause spaces may also disposed between at least some of the frames in the burst. Characteristics of the frames in the burst and of the burst itself may be selected based upon one or more criteria such as government standards, industry requirements, periodicity requirements, or power requirements. Other examples of criteria are possible.

The above-mentioned characteristics of the signal that are adjusted based upon the criteria may include the total number of frames in the burst, the relative positioning of the frames within the burst, the number of frames in the burst from each of plurality of manufacturers, and the relative positioning of the frames within the burst wherein at least some of the frames are from different manufacturers. Other examples of characteristics may also be adjusted.

In one aspect, the power requirement of the frames allows a first power level for a first burst and a second power level for a second burst, the first burst shorter than the second burst, and the first power level being greater than the second power level. In another aspect, the industry requirement relates to the amount of time required to complete a localization process. In still another aspect, the government standard relates to the maximum on-air time for a burst.

Referring to FIG. **6**, a tire pressure monitoring system **600** is shown assembled within a vehicle **602**. The system **600** includes a receiver **606** that receives communications from tire pressure monitoring devices **604** ("monitors") assembled within each of the vehicle's tires **608**. The receiver **606** may be any communication device configured to receive any type of transmitted communication but tuned to only recognize some of these communications. In one example, these communications are radio frequency (RF) communications, but other types of communications are also possible.

Although the device **604** is described as a tire pressure monitoring device herein, it will be appreciated that this device can gather and transmit other types of information related to the tire in addition to or in place of tire pressure information. For example, the information can include temperature information or information related to the wear of the treads of the tire. Appropriate sensors or sensing devices may be used to obtain this information. Other examples of information may also be gathered by the tire pressure monitoring device **604**.

Each of the tire pressure monitoring devices **604** are assembled within the tires **608** of the vehicle **602** and, as mentioned, communicate information indicative of conditions within the tires **608** to the receiver **606**. These conditions include temperature, pressure, and/or any other desired information that aids in the evaluation of tire conditions. Other examples of conditions may also be sensed.

The system **600** includes the tire pressure monitoring devices **604** that in this example includes a memory device **626**. The memory device **626** is utilized for the storage of a control program **628**. The control program **628**, once compiled and executed, transmits sensed information (e.g., tire pressure information) according to one or more protocols (or formats) that govern operation and communication between the tire pressure monitoring device **604** and the receiver **606**. Examples of communication protocols that may be used include protocols that specify the frequency and timing of transmissions from the tire pressure monitoring device **604** to the receiver **606** or the format of transmission (such as what constitutes a "1" or a "0," modulation type, error detection and/or correction content, synchronization pattern, and so forth to name but a few examples in these regards). Tire pressure monitoring information may be transmitted according to the protocols sequentially (e.g., using the same antenna) or at the same time (e.g., using different antennas). No separate manufacturers' codes are used in making the transmissions. Once the control program is compiled, the protocols that have been selected cannot be changed without changing (e.g., editing, compiling, and installing anew) the control program **628**. In one aspect, the control program **628** is compiled and stored in the memory **626** during manufacturing.

In one aspect, the control program **628** may be executed continuously whenever the vehicle is moving. The control program **628** may also be executed when the vehicle is not moving, but only when the sensor is activated externally (i.e., via LF or grounding of a pin on the ASIC during manufacturing). At other times, it may not be executed. However, learning the identities of the devices **604** and/or determining where each device is located ("localization", e.g., front left, front right, and so forth) may be accomplished by using an activation device **620**. The activation device **620** emits a wireless signal **622** (e.g., an LF signal) that is received by a corresponding one of the tire pressure monitoring devices **604**. Receipt of the wireless signal **622** causes the device **604** to transmit identity information and also indicate to the receiver **606** that the device **604** has received an LF signal and that the localization process can occur. When the vehicle is moving, LF transmitters (e.g., antennas) may transmit LF signals (in place of the device **620**). When moving, the RF signals are periodically being transmitted and when the device **604** finds an LF signal, it so indicates to the receiver **606** (e.g., by flipping a bit in the RF transmission). Once this indication is received, localization can be completed (e.g., this process may occur for a predetermined amount of time to ensure that the device **604** is correctly localized). Once localization is complete, tire pressure information can be associated with a known tire. It will be appreciated that in other examples, the control program may itself be activated by the LF signals.

The activation device **620** includes a series of selectable buttons **624** (or other types of actuators) that are actuated by a user to indicate that they wish to activate the tire pressure monitoring device. Although the example device **620** is shown with buttons, other display and selection configurations, such as touch screens, switches or some other selection interface may be used as will be appreciated by those skilled in the art. Accordingly, installation of the multi-application tire pressure monitoring devices **604** optionally includes the initial step of physically activating the tire pressure monitoring devices **604** within each of the corresponding tires **608** or activating a localization process that allows tire pressure data to be associated with particular tires.

If an activation device is used, the activation device **620** is placed proximate to each of the tire pressure monitoring devices **604** to send a signal **622**. In one example, the signal **622** is a low frequency transmission received by the proximate tire pressure monitoring device **604**.

The devices **604** operate with the receiver **606** in the vehicle and the receiver **606** typically has a display (or some sort of user interface) that is configured to alert the driver when the tire pressure falls below a predetermined threshold value. As mentioned, once physically installed in the tire, the devices **604** are first "learned" by the control unit. During this process, the receiver **606** determines the particular identifiers and during or after learning, a localization process may be executed in which each of the devices **604** is associated with a particular tire.

During normal operation (after the sensors are learned and localized and the vehicle is moving), the device **604** senses the tire pressure and sends a radio frequency (RF) signal to the receiver **606** indicating the tire pressure. The receiver **606** can then determine if a pressure problem exists. If a problem exists, the user can be alerted so that appropriate action can be taken. As mentioned, this is all accomplished by use of a control program that is compiled, translated, and/or assembled before it is executed. In one aspect, once compiled the structure of the control program (e.g., the protocols selected) cannot be changed. Also, nothing external to the device can be input into this control program to change the structure of the control program once the control program (and the protocols specified in the control program) is compiled.

As mentioned, the devices **604** transmit tire pressure information. The signals that are transmitted include bursts that themselves include plurality of frames and each of the frames includes the tire pressure monitoring information. A plurality of pause spaces may be disposed between at least some of the frames in the burst. Characteristics of the frames in the burst or of the burst itself may be configured based upon criteria such as government standards, industry requirements, receiver requirements, periodicity requirements, or power requirements. Other examples of criteria are possible.

The characteristics of the signal may include the total number of frames in the burst, the relative positioning of the frames within the burst, the number of frames in the burst from each of plurality of manufacturers, and the relative positioning of the frames within the burst wherein at least some of the frames are from different manufacturers. Other examples of characteristics are possible.

The devices **604** can also receive indications as to whether the vehicle is moving. For example, a signal can be sent from the control unit of the vehicle with this information or the device may include an accelerometer.

Referring now to FIG. **7**, one example of an approach for transmitting sensed tire pressure information is described. At step **702**, the tire pressure information is sensed. This can be accomplished by any tire pressure sensing mechanism as known to those skilled in the art.

At step **704**, the sensed tire pressure information is stored in a transmission buffer. The transmission buffer may be part of a memory.

At step **706**, a control program is executed to transmit the tire pressure information from the transmission buffer to an external receiver device according to each of a plurality of communications formats incorporated into the control program and not according to a manufacturers' code. The control program may be stored in the same memory as the transmission buffer or may be stored in a separate memory unit.

The control program may be compiled and/or assembled prior to its execution. The transmission of information according to each of the protocols may be in predetermined block having a pre-defined format. Thus, separate blocks are used to transmit tire pressure information for different protocols. Each of the blocks may be transmitted sequentially in a burst. A null space may be used to separate each of the blocks in the burst.

As mentioned, the transmission buffer is configured to store tire pressure monitoring data and the transmitter is configured to transmit a signal including the tire pressure monitoring data. The signal includes a burst that includes plurality of frames and each of the frames includes the tire pressure monitoring information. A plurality of pause spaces in some examples are disposed between at least some of the frames in the burst. Characteristics of the frames in the burst may be selected based upon criteria such as government standards, industry requirements, periodicity requirements, or power requirements. Other examples of criteria are possible.

The characteristics of the signal (e.g., that are adjusted to meet government standards, industry requirements, receiver requirements, periodicity requirements, and/or power requirements) may include the total number of frames in the burst, the relative positioning of the frames within the burst, the number of frames in the burst from each of plurality of manufacturers, and the relative positioning of the frames within the burst wherein at least some of the frames are from different manufacturers. Other examples are possible.

At step **708**, the external receiver device may be configured to operate according to a selected one of the plurality of communication protocols. At the external receiver device (that is configured to operate according to a selected one of the plurality of communication protocols) receives the tire pressure information transmitted. At step **710**, the receiver recognizes the tire pressure information transmitted according to the selected one of the plurality of communication protocols and ignores the tire pressure information transmitted according to others of the plurality of communication protocols.

Referring now to FIG. **8**, an apparatus **800** for sensing tire pressure information is described. The apparatus **800** includes a sensor **802**, a transmission buffer **804**, a memory **806**, a transmitter **808**, and a processor **810**. One or more antennas **809** transmit RF signals with the tire pressure information (e.g., in blocks, the blocks serially transmitted in bursts, each block having a predetermined format). One or more antennas **811** receive other communications (e.g., LF communications) that activate the apparatus **800** to transmit the RF signals.

The sensor **802** that is configured to sense tire pressure information of a tire. The sensor **802** is any mechanical or electrical sensing arrangement that senses the pressure of the tire as know to those skilled in the art.

The transmission buffer **804** is communicatively coupled to the sensing device and is configured to store the sensed tire pressure information. The transmission buffer **804** may be part of the memory **806** or separate from the memory **806** and is configured to store tire pressure monitoring data. The memory **806** may be any type of memory storage device.

The transmitter **808** is coupled to the transmission buffer **804** and is configured to transmit signals. The transmitter **808** may have one or more antennas **809** to transmit the signals. As mentioned, one or more antennas **811** receive other communications (e.g., LF communications) that activate the apparatus **800** to transmit the RF signals. These antennas may be coupled to the processor **810**, which determines whether the signals meet criteria that are required to activate the apparatus **800** and thereby begin transmitting the tire pressure information. The signal includes a burst that includes plurality of frames and each of the frames includes the tire pressure monitoring information. A plurality of pause spaces is disposed between at least some of the frames in the burst. Characteristics of the frames in the burst may be selected based upon one or more of: government standards, industry requirements, receiver requirements, periodicity requirements, or power requirements. Other examples are possible.

The characteristics of the signal relate to at least one characteristic such as the total number of frames in the burst, the relative positioning of the frames within the burst, the number of frames in the burst from each of plurality of manufacturers, and the relative positioning of the frames within the burst wherein at least some of the frames are from different manufacturers. Other examples are possible.

The processor **810** is communicatively coupled to the sensor **802**, the transmitter **808**, the transmission buffer **804**, and the memory **806**. The processor **810** is configured to execute a control program stored in a memory and execution of the control program is effective to transmit the tire pressure information from the transmission buffer **804** to an external receiver via the transmitter **808** according to each of a plurality of communications formats incorporated into the control program and not according to a manufacturers' code.

In other aspects, a receiver **820** is configured to receive the tire pressure information transmitted according to each of the plurality of communication protocols that is transmitted by the transmitter **808** at antenna **824** and communicate the information to processor **822** where the information can be processed. The receiver **820** is further configured to recognize the tire pressure information transmitted according to a selected one of the plurality of communication protocols and ignore the tire pressure information transmitted according to non-selected ones of the plurality of communication protocols.

Referring now to FIG. **9**, one example of RF transmissions is described. In this example, a first burst **902** includes blocks (or frames) **904**, **906**, and **908**. A second burst **920** includes frames **922**, **924**, and **926**. Null frames **910** are inserted between the frames, **906**, **908**, **910**, **922**, **924**, and **926**.

Each of the blocks or frames **904**, **906**, **908**, **922**, **924**, and **926** includes tire pressure information. This information may be in the same or different formats. In one example, all frames **904**, **906**, **908**, **922**, **924**, and **926** include the information according to the protocol of a first manufacturer. In another example, frame **904** is in the protocol of a first manufacturer, frame **906** is according to the protocol of a second manufacturer, frame **908** is in the protocol of the first manufacturer, frame **922** is in the protocol of a third manufacturer, frame **924** is according to the protocol of a fourth manufacturer, and frame **926** is according to the protocol of a fifth manufacturer. In still another example, the frames are in the format of completely different manufacturers. In other aspects, a manufacturer may have different formats. For instance, a first manufacturer may have a first format and a second format.

In one aspect, once the burst is sent, it is repeatedly transmitted. The repetition is immediate and each new burst includes newly updated information transmitted in each frame of the burst. In another example, once the first burst **902** is sent and then a predetermined time later (e.g., 17 seconds) the second burst is sent. Then, the pattern is repeated.

In one aspect, the burst pattern cannot be changed by the user without the control program being entirely re-programmed. That is, a programming tool cannot be used to change the control program to transmit frames for additional/different manufacturers and cannot be used to select frames to transmit.

Referring now to FIG. **10**, one example of protocol arrangement is described. As used herein, the term "protocol arrangement" refers to the arrangement of particular manufacturers' frames within a burst so as to meet a predefined criteria. As shown in FIG. **5**, the structure of six example bursts is shown. The frames are formatted according to the protocol of Manufacturer 1, with a first format (M1, F1); Manufacturer 1, with a second format (M1, F2); Manufacturer 1, with a third format (M1, F3); Manufacturer 2, with a single format (M2); Manufacturer 3, with a first format (M3, F1); Manufacturer 3, with a second format (M3, F2); Manufacturer 4, with a first format (M4, F1); and Manufacturer 4, with a second format (M4, F2). Pauses (P) are placed between the content-bearing frames. The length of each frame can vary. By "format", it is meant the arrangement and contents of a frame such as the number of bits, the existence of certain fields, the arrangement of the fields, the existence of a checksum field, to mention a few examples.

It will be appreciated that various characteristics of the burst can be changed in the protocol arrangement. These characteristics can include the total number of frames in the burst, the relative positioning of the frames within the burst with respect to each other, the number of frames in the burst from each of plurality of manufacturers, the relative positioning of the frames within the burst where at least some of the frames are from different manufacturers, the frame that leads the burst, to mention a few examples. It will be appreciated that these characteristics can be adjusted based upon a variety of factors such as government standards, industry requirements, periodicity requirements, and power requirements of the transmitted signal and other system functional requirements. Other examples of characteristics and sources that affect/define these characteristics are possible.

It will be further understood that the particular factors used to select frames (i.e., that are transmitted according to a particular manufacturers' protocol) can vary and that the exact selection varies depending upon the factors mentioned above. These factors can be adjusted to meet the needs of a particular user or system. It will be further appreciated that government and/or industry requirements can change over time, but the approaches herein can take into account any such changes, modifications, additions, or deletions to these requirements.

To take one example, the Federal Communications Commission (FCC) has a requirement that an on-the-air signal can not exceed one second. Further, the periodicity of a burst is also a FCC requirement and is required to be: P=on-the-air time*30, or 10 seconds, whichever is greatest. A manufacturer may have a periodicity requirement that a burst (or frame) be transmitted every 17 seconds (e.g., because of localization requirements of the manufacturer or so other requirement affecting periodicity). In this case, with P=17, the on-the-air time is approximately 500 ms.

Thus, transmissions can be made from each of the wheel units (four, one for each tire) as shown in FIG. **11** with, for example, a duration of 500 ms. As shown, each wheel unit (monitor) sends a burst every 17 seconds. The first burst may be the first burst of FIG. **10**, the second burst the second burst of FIG. **10**, the third burst, the third burst of FIG. **10**, and so forth (for simplicity, the third, fourth, fifth and sixth burst are not shown in FIG. **10**).

In other examples, the FCC has stated that for a particular frequency the average power cannot exceed 67.5 db uV/m at three meters. However, for small duration signals, this may be increased by 20 db to 87.5 db uV/m. To determine if a particular portion of a burst exceeds the maximum of 20 db (for a peak value), the base 10 log of (on-the-air time of a frame/100 ms)*20 is taken and this is referred to an averaging factor. Here, the on-the-air time is of the frame itself and does include pauses. For instance, for a frame having a duration of 10 ms, the average factor is 20 db. For a frame with a duration of 20 ms, the averaging factor is 10 db. Thus, in the later case, the averaging factor can be increased by 10 db, for example, by changing the frame to be that of a different manufacturer to increase the duration and the averaging factor. In this example, the frames within the burst are adjusted to obtain (or attempt to obtain) the maximum power at that portion of the burst.

In still other aspects, the number of frames of a particular manufacturer in a burst can be adjusted. For example, some manufacturers require that two or three frames of that manufacturer be transmitted in a burst. The number of frames of a particular manufacturer may also be adjusted depending upon whether the frames are transmitted according to FSK or ASK modulation. For instance, FSK is less susceptible to noise than ASK, so if the frames are ASK-transmitted, more of the ASK type frames may need to be transmitted. The order of frames within a burst can also be adjusted. For example, two frames from a single manufacturer may be transmitted with one frame at the beginning and the other in the middle or end of the burst to avoid noise problems since it is more likely that two frames placed together will be affected by noise rather than two frames spaced apart.

It should be understood that any of the devices described herein (e.g., the programming or activation devices, the tire pressure monitoring devices, the receivers, the transmitters, the sensors, the presentation devices, or the external devices) may use a computing device to implement various functionality and operation of these devices. In terms of hardware architecture, such a computing device can include but is not limited to a processor, a memory, and one or more input and/or output (I/O) device interface(s) that are communicatively coupled via a local interface. The local interface can include, for example but not limited to, one or more buses and/or other wired or wireless connections. The processor may be a hardware device for executing software, particularly software stored in memory. The processor can be a custom made or commercially available processor, a central processing unit (CPU), an auxiliary processor among several processors associated with the computing device, a semiconductor based microprocessor (in the form of a microchip or chip set) or generally any device for executing software instructions.

The memory devices described herein can include any one or combination of volatile memory elements (e.g., random access memory (RAM), such as dynamic RAM (DRAM), static RAM (SRAM), synchronous dynamic RAM (SDRAM), video RAM (VRAM), and so forth)) and/or nonvolatile memory elements (e.g., read only memory (ROM), hard drive, tape, CD-ROM, and so forth). Moreover, the memory may incorporate electronic, magnetic, optical, and/or other types of storage media. The memory can also have a distributed architecture, where various components are situated remotely from one another, but can be accessed by the processor.

The software in any of the memory devices described herein may include one or more separate programs, each of which includes an ordered listing of executable instructions for implementing the functions described herein. When constructed as a source program, the program is translated via a compiler, assembler, interpreter, or the like, which may or may not be included within the memory.

It will be appreciated that any of the approaches described herein can be implemented at least in part as computer instructions stored on a computer media (e.g., a computer memory as described above) and these instructions can be executed on a processing device such as a microprocessor. However, these approaches can be implemented as any combination of electronic hardware and/or software.

Those skilled in the art will recognize that a wide variety of modifications, alterations, and combinations can be made with respect to the above described embodiments without departing from the spirit and scope of the invention, and that such modifications, alterations, and combinations are to be viewed as being within the scope of the invention.

What is claimed is:

1. A method of forming a burst of frames for transmission in a tire pressure monitoring system, the method comprising: adjusting a number of frames in a burst such that a first optimal number of first frames from a first manufacturer are included in the burst, the first optimal number of frames chosen to enable the detection of the burst by first receivers that are tuned to receive the first frames from the first manufacturer;

adjusting the number of frames in the burst such that a second optimal number of second frames from a second manufacturer are included in the burst, the second optimal number of frames chosen to enable detection of the burst by second receivers that are tuned to receive the second frames from the second manufacturer;

wherein the number of frames in the burst maintains a configuration compliant with government regulations regarding one or more of a burst length and a power emission, wherein the burst comprises an on-the-air signal and the on-the-air signal does not exceed one second, wherein the burst is transmitted at a particular frequency and the average power does not exceed 67.5 db uV/m at three meters, and wherein the burst configuration cannot be changed by the user without a control program being entirely re-programmed.

2. The method of claim **1**, wherein the burst has a configuration compliant with an industry requirement.

3. The method of claim **2**, wherein the industry requirement relates to the amount of time required to complete a localization process.

4. An apparatus for transmitting tire pressure signals, the apparatus comprising: a transmission buffer configured to store tire pressure monitoring information; a transmitter configured to transmit a signal including the tire pressure monitoring information, the signal comprising: a burst with an adjustable number of frames such that a first optimal number of first frames from a first manufacturer are included in the burst, the first optimal number of frames chosen to enable the detection of the burst by first receivers that are tuned to receive the first frames from the first manufacturer; such that a second optimal number of second frames from a second manufacturer are included in the burst, the second optimal number of frames chosen to enable detection of the burst by second receivers that are tuned to receive the second frames from the second manufacturer; wherein the burst maintains a configuration compliant with government regulations regarding a one or more of a burst length and a power emission, wherein the burst comprises an on-the-air signal and the on-the-air signal does not exceed one second, wherein the burst is transmitted at a particular frequency and the average power does not exceed 67.5 db uV/m at three meters, and wherein the burst configuration cannot be changed by the user without a control program being entirely re-programmed.

5. The apparatus of claim **4**, wherein the burst has a configuration compliant with an industry requirement.

6. The apparatus of claim **5**, wherein the industry requirement relates to the amount of time required to complete a localization process.

7. A method of forming a burst of frames for transmission in a tire pressure monitoring system, the method comprising:

disposing first frames of a first manufacturer at a first position in a burst, and disposing second frames of a second manufacturer at a second position in the burst, the first position being sequentially earlier in time than the second position; wherein the length of the first frames is shorter than the length of the second frames; wherein the burst pattern cannot be changed by the user without the control program being entirely re-programmed, wherein the burst comprises an on-the-air signal and the on-the-air signal does not exceed one second, wherein the burst is transmitted at a particular frequency and the average power does not exceed 67.5 db uV/m at three meters, and wherein the burst configuration cannot be changed by the user without a control program being entirely re-programmed.

8. The method of claim **7**, wherein the burst has a configuration compliant with an industry requirement.

9. The method of claim **8**, wherein the industry requirement relates to the amount of time required to complete a localization process.

10. An apparatus for transmitting tire pressure signals, the apparatus comprising: a transmission buffer configured to store tire pressure monitoring information;

a transmitter configured to transmit a signal including the tire pressure monitoring information, the signal comprising: a burst including first frames of a first manufacturer at a first position in the burst, and second frames of a second manufacturer at a second position in the burst, the first position being sequentially earlier in time than the second position; wherein the length of the first frames is shorter than the length of the second frames; wherein the burst pattern cannot be changed by the user without the control program being entirely re-programmed, wherein the burst comprises an on-the-air signal and the on-the-air signal does not exceed one second, wherein the burst is transmitted at a particular frequency and the average power does not exceed 67.5 db uV/m at three meters, and wherein the burst configuration cannot be changed by the user without a control program being entirely re-programmed.

11. The apparatus of claim **10**, wherein the burst has a configuration compliant with an industry requirement.

12. The apparatus of claim **11**, wherein the industry requirement relates to the amount of time required to complete a localization process.

13. A non-transitory computer usable medium having a computer readable program code embodied therein, said computer readable program code adapted to be executed to implement a method, the method comprising: adjusting a number of frames in a burst such that a first optimal number of first frames from a first manufacturer are included in the burst, the first optimal number of frames chosen to enable the detection of the burst by first receivers that are tuned to receive the first frames from the first manufacturer;

adjusting the number of frames in the burst such that a second optimal number of second frames from a second manufacturer are included in the burst, the second optimal number of frames chosen to enable detection of the burst by second receivers that are tuned to receive the second frames from the second manufacturer;

wherein the burst maintains a configuration compliant with government regulations regarding one or more of a burst length and a power emission, wherein the burst comprises an on-the-air signal and the on-the-air signal does not exceed one second, wherein the burst is transmitted at a particular frequency and the average power does not exceed 67.5 db uV/m at three meters, and wherein the burst configuration cannot be changed by the user without a control program being entirely re-programmed.

14. A non-transitory computer usable medium having a computer readable program code embodied therein, said computer readable program code adapted to be executed to implement a method, the method comprising: disposing first frames of a first manufacturer at a first position in a burst, and disposing second frames of a second manufacturer at a second position in the burst, the first position being sequentially earlier than the second position; wherein the length of the first frames is shorter than the length of the second frames; wherein the burst pattern cannot be changed by the user without the control program being entirely re-programmed, wherein the burst comprises an on-the-air signal and the on-the-air signal does not exceed one second, wherein the burst is transmitted at a particular frequency and the average power does not exceed 67.5 db uV/m at three meters, and wherein the burst configuration cannot be changed by the user without a control program being entirely re-programmed.

* * * * *